CHAPTER III

Development and Applications of Tests of Intellectual and Special Aptitudes

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THE CONCEPTION of fundamental differential aptitudes and the basic research aimed at their discovery were not taken seriously until Thurstone proposed his theory of multiple factors and carried out the first comprehensive factor-analytic study from this point of view, a little more than two decades ago (82). Since that time there has been substantial development along this line in the further work of Thurstone and his associates and in the Air Force wartime research on classification tests (40). By the end of the war, about 25 primary mental abilities (not all of them in the general intellectual area) had been found by Thurstone's methods of analysis. Many of them were demonstrated to have some importance in the selection and classification of aircraft pilots, navigators, bombardiers, and other aircrew personnel.

Since the war, the highest concentration of research along the same lines has been in connection with the project on Aptitudes of High-Level Personnel, at the University of Southern California.[1] In this project, the prevailing technique has represented a wedding of factor analysis with experimental method. The kinds of tasks or tests have been varied systematically, both qualitatively and quantitatively, according to hypotheses generated concerning the existence of certain primary intellectual abilities and concerning their properties. The batteries of tests have been administered to military personnel who were entering upon courses of training that in most cases led to the status of commissioned officers. The intellectual abilities under investigation were included under the heuristic categories of reasoning, creative thinking, evaluation, planning, and problem solving. Since the initiation of the project in 1949, a dozen major factor-analytic studies have been carried out, some of which have been reported recently (5, 50).

One of the obvious consequences of these studies is the continued indication that human intellect is a very complex phenomenon. The possibility that there is a unitary trait of intelligence, at least at adult levels, grows more remote. This is not a necessary consequence of the use of multiple-factor analysis. The results of an analysis are determined by the intercorrelations of the test scores. When tests are varied sufficiently in kind, zero correlations are numerous. The strongest logical support for the belief in a general intellectual factor has been the assertion that tests of intellectual abilities universally intercorrelate positively. This assertion is definitely not consistent with the facts.

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[1] Under contract N60nr-23810 with the Office of Naval Research.

Another consequence has been the discovery and verification of primary abilities in new areas such as creative thinking and planning. This is partly attributable to the use of new varieties of tests, but especially to a willingness to utilize tests of the completion or open-end type, tests that even require some subjective judgment in scoring. It does not seem to be possible to measure some of the more obviously creative talents by means of multiple-choice tests or other types of tests in which responses are not produced by the examinee but are presented to him. One implication of this is that an overwhelming emphasis upon completely objective testing could have serious educational consequences. Achievement tests, particularly, embody educational objectives and implement an educational philosophy, expressed or unexpressed.

Perhaps the most significant consequences have been the implications of the intellectual factors (a) for the assessment of individuals, (b) for the education of children and youth, and (c) for an understanding of intellect itself. Since the first two of these follow from the third, the picture of the nature of intellect that grows out of the studies will be presented briefly. From this picture, other implications may be readily deduced.

The Structure of Intellect

With the growing numbers of primary abilities discovered, it became increasingly important to attempt to find some unifying principles that would make possible an easier comprehension of the total list. Attempts to classify the factors have proved to be moderately successful, and in the process some significant principles of organization have emerged. This would not have been possible without the available knowledge of a sufficient number and variety of factors. The result of these attempts has been called a "structure of intellect" (34, 36, 37, 38). Although the organization of intellectual factors in a unified system, like most general theories, will probably undergo many changes as new information accumulates, in its present form it has proven very helpful in guiding further factorial research, and it seems to offer concepts that will be useful to the experimental psychologist as well as to the educator. Following is the authors' summary of the present viewpoint (some authorities, e.g., Burt, would not agree with this analysis; see Chapter II of this REVIEW).

The first and most obvious principle regarding the structure of intellect is that primary abilities differ according to the kind of material or content dealt with by the individual. For a long time we have had the recognition of a distinction between verbal and nonverbal tests. There prove to be verbal and nonverbal factors of intellect. But the nonverbal category subdivides into *two* classes of abilities. There are abilities to deal with "figural" material (concrete, perceived forms, and properties) on the one hand, and abilities to deal with "symbolic" material (composed of letters, numbers, and the like) on the other. In the verbal category are abilities for dealing with concepts or meanings; hence, the third class of factors has been called "semantic." There are parallel abilities for dealing with the three kinds of content—figural, symbolic, and semantic.

Within each of the three categories as to content, factors differ with respect to the kinds of operations performed on the material. There are basically five kinds of operations as indicated by five kinds of factors. One operation is that of cognition, which simply has to do with knowing information. We discover or recognize perceived objects and their properties, we discover or recognize symbolic units, such as words and other expressions, and we discover or recognize meanings. A second kind of operation is that of memory or retention. An individual's memory is not equally good for all kinds of material or all kinds of information.

The third and fourth kinds of operations have to do with productive thinking. Productive thinking is involved when from given information some other information is generated. But it makes a difference whether the conclusion or other outcome is a unique one that is essentially determined by the information given or whether the generated information can be varied or must be varied, alternative outcomes being not only possible but also sometimes demanded. The former pertains to convergent thinking, thinking that converges upon the unique consequence. The latter pertains to divergent thinking, thinking that goes searching, changes route, and yields multiple answers. It is in the divergent-thinking category that we find the abilities most clearly associated with creative performance—fluency of thinking, flexibility of thinking, and originality.

The fifth kind of operation is evaluation. We are perpetually checking and rechecking our information, our memories, and our productions, convergent or divergent. In this connection we make use of feedback information that helps us to arrive at decisions as to the correctness, goodness, appropriateness, or suitability of our cognitions, memories, and conclusions. There is a set of evaluative abilities parallel to the productive-thinking abilities, memory abilities, and cognitive abilities.

The third major principle of classification of the primary intellectual abilities is in terms of the kinds of products achieved by the different kinds of operations applied to the different kinds of contents. We are not certain, as yet, that the same list of kinds of products applies in the case of every kind of operation and every kind of content, but enough is known to suggest that this may be so.

Six kinds of products have been recognized, and each kind results from the various kinds of operations. The kinds of products are units of information, classes of units, relations between units, patterns or systems of information, transformations, and implications. A few examples will show how operations, contents, and products combine in connection with factors. We cognize units of information in figural form. We remember related (associated) units of information in semantic form (ideas). A flexible thinker readily transforms information that comes to him in symbolic form, which suggests that he might be indulging in mathematical thinking to produce or to arrive at new information.

A Comprehensive Theory of Intellect

With three kinds of content, five kinds of operations, and six kinds of products involved in intellectual performances, there should be 3 x 5 x 6, or 90, primary intellectual abilities. About 50 of the primary intellectual abilities are now known through factorial investigations. It might thus seem that more than half of the possible intellectual factors are known, but there are other considerations that suggest that more than 90 potential factors exist.

There is much empirical evidence of a nonfactorial nature concerning an area of intellect that is sometimes called "social intelligence" and more often recently called "empathy" or "empathic ability." As commonly conceived and investigated, this area of abilities pertains to the cognition of the thoughts, feelings, and attitudes of perceived individuals. If we think by analogy to what is known about recognized intellectual abilities, we may suppose that in the area of empathy we are dealing with a fourth kind of content, namely, a kind of material that may be designated as "behavioral."

Carrying the analogy further, we may hypothesize that the abilities for dealing with behavioral content are parallel to those already known (or predicted) in connection with the other kinds of content. The same operations theoretically apply so that besides abilities to cognize the behavior of others we have separate abilities for remembering behavior, for doing productive thinking about it, convergent and divergent, and for evaluating our cognitions and conclusions about it. Products of behavioral intellectual operations would be expected to fall in the same six categories—units, classes, relations, systems, transformations, and implications.

With the category of behavioral intelligence added, the comprehensive theory of human intellect, which has been elaborated in sketchy form, can be illustrated by means of a geometric model as in Figure I. The three principles of classification of the primary abilities are represented by the three dimensions of the cubical model. The order of the categories in each dimension is logical but not firmly fixed since we lack the criteria for establishing unique orders. There is little doubt that some of the intellectual factors have common linkages within individuals and would, therefore, exhibit some positive intercorrelations in populations. A reasonable, general prediction would be that correlations between factors are in direct proportion to proximity within the system when the orders of the categories are properly arranged.[2]

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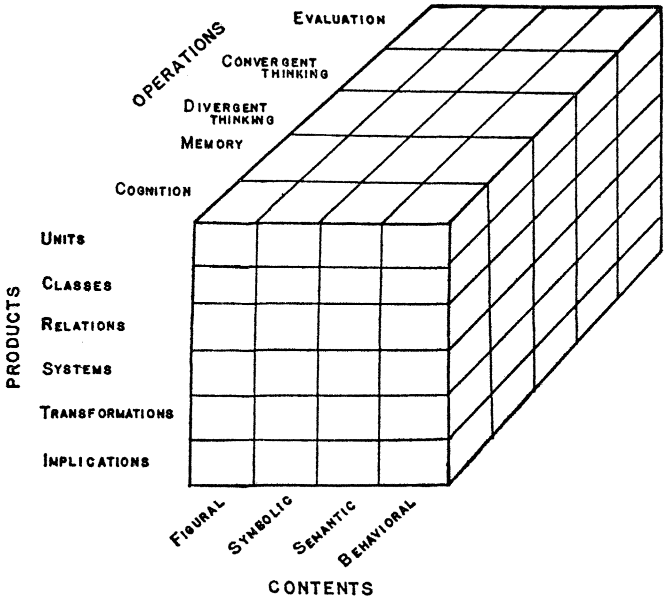
[2] Similar dimensional models for classifying primary traits have been found useful in the area of psychomotor abilities (39).

FIGURE I



THEORETICAL MODEL FOR THE COMPLETE "STRUCTURE OF INTELLECT"

Besides providing the basic variables along which individuals should be evaluated for various purposes, the structure of intellect suggests certain general implications for education. It may become popular, once again, to speak of education as development of the mind or of intellect. Knowing the intellectual abilities in all their variety and knowing their properties, we are in a much better position to suggest the course content and the procedures of instruction that should promote their improvement to the extent that they can be improved. In terms of learning theory, the implication definitely favors a cognitive bias in preference to the present stimulus-response bias. According to the cognitive view, the organism is an agent that discovers information, remembers information, and uses information in productive thinking and in evaluating any of its intellectual products. Such a view should have its consequences in the modification of philosophy of education with potentially far-reaching effects.

Tests of Differential Aptitudes (Aptitude Test Batteries)

Having looked at the theoretical aspects, we now turn to a review of the literature on applications of tests of special aptitudes for the period July 1955 to July 1958. *The Proceedings of the 1955 Invitational Con-*

ference on Testing Problems (2, 14, 29, 68) reported a series of papers on the use of multifactor ability test batteries in counseling and guidance. North (68) reported that counselors are making increased use of multifactor tests for differential predictions of academic and vocational success. These tests will become more useful in the school situation as reliability, validity, norms, and the theoretical framework of the factor scores are better determined. The general intelligence test still is useful in school counseling, however, especially at the elementary-school level. Anderson (2) described the *General Aptitude Test Battery (GATB)* and its use by the U. S. Employment Service. She pointed out that this battery provides the examinee with an Individual Aptitude Profile, covering nine aptitudes, as well as Occupational Aptitude Patterns, which indicate for which families of jobs the examinee is suited. Cureton (14) presented detailed descriptions of 16 batteries in tabular form. His presentation is of especial interest to counselors and others who must make some choice among the various published test batteries. French (29) concluded the session with a discussion of the logic of and assumptions underlying differential testing; every research worker and person interested in this problem should read this exposition carefully.

Michael (62) surveyed the field of differential testing with respect to the selection and placement of high-level personnel and considered a number of theoretical problems involved. Super (80) introduced a series of 10 articles on the use of multifactor test batteries in guidance, which appeared in the *Personnel and Guidance Journal,* by discussing the desiderata of guidance tests, the peculiarities of multifactor test batteries, the characteristics of available batteries, and implications for counseling. In each of the next eight articles one of the authors of a multifactor test battery presented the battery's origin, applicability, content, administration and scoring, norms, standardization and initial validation, reliability, validity, and use in counseling and selection. The test batteries reviewed were the *Differential Aptitude Tests (DAT)* (4), *General Aptitude Test Battery (GATB)* (18), *Guilford-Zimmerman Aptitude Survey* (35), *Holzinger-Crowder Uni-Factor Tests* (13), *Factored Aptitude Series of Business and Industrial Tests* (51), *Multiple Aptitude Tests* (76), *Flanagan Aptitude Classification Tests* (20), and *Tests of Primary Mental Abilities (PMA)* (83). Critical comments by Super were printed immediately following each article.

Super (79), in the final article of the series, provided a summary evaluation of each battery. He listed two batteries which he considered ready for use in counseling, four batteries he considered ready for research use only, and two he considered completely unsuitable for use at the present time.

Bennett (3) in a questionnaire study with a 59-percent return, reported that the *DAT* showed profile differences among high-school students who later entered various occupational and educational careers. Vineyard (85), in another longitudinal study, examined the relationship between scores obtained early in high school and academic success in the freshman year of college. By means of multiple discriminant analysis Hall (42) determined similarities and differences between counselee groups; he was also able to determine a probability value for occupational and educational group membership for any subsequent examinee taking the *DAT* battery. Brayfield and Marsh (9) described the aptitude profiles of 50 farmers on the *DAT* battery. As compared with twelfth-grade students, these farmers excelled somewhat in *Mechanical Reasoning* but were average or below in the other aptitudes measured. Correlations with job performance measures were low, and relationship with job satisfaction was essentially zero.

Isaacson (47) used *GATB* scores and measures of general aptitude, interests, and personality traits to predict successful participation in a school's work experience program. Only one of the *GATB* scores—*General Intelligence*—was among the four measures found to be valid, the other three being measures of interest and personality. Retest performances on six tests of the *GATB* were investigated by Sorenson and Senior (77); one group was retested after four weeks, and a second group was retested after four years. Substantial gains were reported for most of the tests: For *Spatial Aptitude, Reasoning,* and *General Intelligence* scores the four-week gain was greater, while for *Verbal* and *Clerical Aptitide* scores the four-year gain was larger. A complication in interpreting the results was that the initial level of aptitude for the four-week group was lower than that for the four-year group.

A new manual for the *Guilford-Zimmerman Aptitude Survey* (41), containing additional information about research findings concerning these tests, was issued.

Mitchell (64) investigated the extent to which each of the four factor scores and a weighted composite score on the *Holzinger-Crowder Uni-Factor Tests* would predict high-school achievement in 14 communities. Nine of the 10 multiple correlations presented fell in the range .62 to .78. Bond and Clymer (7) reported that most of the *PMA* scores correlated significantly with reading ability, the *Space* test being the most notable exception.

The *Multi-Aptitude Test* (15) represents a multifactor test battery designed for purposes entirely different from those of the batteries considered previously. This battery of tests was developed specifically for demonstration, study, and practice use in tests and measurements courses, civic groups, layman conferences, and the like. French (28) analyzed a battery of pure-factor tests and criterion measures for a large sample of West Point plebes. The factor tests came out on the predicted factors with the exception of the *Space* tests which formed a cluster in the plane defined by the *Induction* and *Visualization* factors. The other factors were sufficiently independent to make it reasonable for them to be represented in a reference battery by a single pure test from each cluster.

Clerical and Mechanical Aptitudes

Several tests of clerical aptitude have been studied and validated. Hughes and McNamara (46) found the *Short Employment Tests* and the *General Clerical Tests* to be highly related, with a possible consequent saving in administration time in the selection of clerical applicants from use of the former. Prescott (72) validated the *Verbal Skills, Number Skills, Clerical Speed,* and *General Clerical Aptitude* scores of the *Turse Clerical Aptitudes Tests* against teachers' marks, teacher-made tests, and standardized tests on samples of commercial course students in two large high schools. The aptitude tests were administered at the beginning of the school year, and the criterion measures were obtained near the end of the school year. Interested in the problem of validity, Lawshe and Steinberg (55) made an important exploratory investigation of the demands of clerical jobs.

The results of two studies indicate the need for further development of the *Minnesota Clerical Test.* Longstaff and Beldo (57) demonstrated that practice effect increases an applicant's score when the currently used form is administered to him more than once. Kirkpatrick (52) found that an alert examinee who noticed that there were more discrepancies toward the end of the items in *Number Checking* and began checking from right to left had a considerable advantage. He recommended revision of the test to distribute the discrepancies more evenly.

McNamara and Hughes (58) administered *Letter-Digit Substitution* and *Name Checking* as well as a number of standardized tests for the selection of card punch operators. Moderate validities against course grades for trainees and somewhat higher validities for supervisors' ratings of employed operators were observed.

Crawford and Crawford (12) standardized an individual apparatus test of fine eye-hand co-ordination and developed percentile norms by sex for several adult job applicant groups.

Fleishman (23) gave a battery of 16 experimental manipulative tests to a sample of airmen engaged in mechanical work to determine whether manipulative tests would add to the validity of the operational battery for a final grade criterion in three technical training schools. He found that two paper-and-pencil tests, *Large Tapping,* and *Discrimination Reaction Time,* and an apparatus test, *Precision Steadiness,* added moderately to the validity of the battery then in use.

In a series of articles Fleishman (21, 24) and Fleishman and Hempel (25) reported the extensive exploratory work in psychomotor skills carried out in the USAF Aviation Psychology Program. Descriptions of the tests and the skills measured are given. Broad group factors of psychomotor skills were found which account for performance on a wide variety of psychomotor tasks. One of the factors was identified as *Integration* and was defined as the "ability to utilize a number of cues and activities quickly in making an integrated response." With extended practice there was a considerable change in the pattern of abilities required to perform complex psychomotor tasks. Abilities which can be measured by printed tests, such as *visualization* and *spatial orientation*, accounted for most variance at early stages of practice, whereas aptitudes measured by apparatus tests such as *speed of arm movement* and *response orientation* were most prominent at later stages of proficiency.

Preference for use of principles over facts in solving problems on the *Balance Problems Test* was shown by Gaier (30) to add significantly to the multiple correlation of the best previously used predictors of final grades in the Air Force Airplane and Engines Mechanics Course. Gordon (32) demonstrated that scores on mechanical information tests should be corrected for amount of mechanical background as determined from biographical information of airmen since there is a negative relationship between background and success in training when the mechanical information score is held constant. Fifty-two items at a difficulty level appropriate for female naval recruits gave a more valid score than all 100 items of a mechanical test for male recruits in a study by Mollenkopf (65).

There have been several studies of the effect of training and background on the spatial visualization abilities. Blade and Watson (6) found that high scores on spatial visualization tests indicate an aptitude for engineering study but suggested that low scores may indicate only a lack of related past experience. Worsencroft (89) observed significant improvement in the spatial relations test scores of engineering students over the course of a year but scarcely any improvement for nonengineering students. He concluded that the improvement of the engineering students was due primarily to training in engineering drawing. Myers (67) observed a different result. Students at the U. S. Naval Academy with previous training in mechanical drawing had, on the average, test scores equal to the scores of those who had not had such training, but the group with the training received significantly better course grades in engineering drawing. Mendicino (61) found no significant differences between matched experimental and control tenth-grade student groups on *DAT Spatial Relations* and *Mechanical Reasoning* scores. The experimental group had taken vocational machine shop and mechanical drawing courses, whereas the control group had not. Michael and his associates (63) reviewed factor analytic studies of the spatial domain, gave definitions, and recommended reference tests for the three principal factors identified.

Artistic Aptitudes

Drake (17) published two forms of a musical aptitude test which yields two reliable scores: *Musical Memory* and *Rhythm.* The test is on microgroove records, and the two scores are reported to have low correlations with each other as well as with age and intelligence. The more difficult *Series B* of the *Seashore Measures of Musical Talent* was discontinued.

The 1956 *Manual* for *Series A* (75) contains references to reliability and validity studies and norms for grades 4 through 16.

Whittington (87) selected a group with musical background and ability to be compared with a nonmusical group. Some of the Wing (88) tests of musical intelligence discriminated between the two groups and were not correlated with tests of manual dexterity. Ottman (69) in a study of skills involved in sight singing in a college music group found that intelligence, language, reading, and *Seashore* measures were not significantly related, but that melodic modulation and hearing intervals with a harmonic background had the highest relationship to skill in sight singing.

Although there was no dearth of studies of the visual arts during the period covered by this review, none was considered worthy of inclusion.

Predicting Success in Professional Training (Professional School Aptitude Batteries)

Morici (66) studied 85 accounting graduates who had taken the *American Institute of Accountants Orientation Test.* For first-year accounting work the total score was most predictive, but for predicting subsequent achievement the *Q* score was the best.

In investigating the prediction of first-year grades at the Emory University Dental School by means of the *Aptitude Tests of the American Dental Association* and by the use of predental grades, Webb (86) reported the results of two studies. Zero-order validity coefficients were low, but the multiple correlations found were .43 and .50.

Jones and Case (49) reported information about an aptitude test battery developed by the Engineering Schools of the University of California at Los Angeles and Berkeley for use with lower-division applicants. While the separate validity coefficients were quite low, multiple correlations of about .50 were obtained. Kirkpatrick (53) investigated the efficiency of a battery of aptitude and personality measures for both the selection and placement of engineers. Harrison, Hunt, and Jackson (43) compared 240 mechanical engineers with the general population with respect to test norms on tests of mental ability. On every test the mean score for the engineers was well above that for the general population, but the engineers seemed to be no more superior on the engineering aptitude tests than on the tests of general intellectual ability. Moreover, the engineers did as well on the verbal tests as on such tests as *Space Relations*, *Mechanical Comprehension*, and *Abstract Thinking*. In an analysis of the specific activities of a large number of engineers, seven distinct areas were identified (19). Interest measures yielded the greatest differentiation among the specialties, next were tests of various abilities, and then came measures of certain personality traits. Boyce (8) tried various methods of combining scores to predict a dichotomous criterion of success in a cooperative engineering program. Gross quantitative methods did as well as refined techniques and showed less shrinkage on cross validation.

A wealth of information with regard to the *Law School Admission Test* is contained in the handbook prepared by Johnson, Olsen, and Winterbottom (48). In addition to discussing the test itself and techniques for using test scores in admissions, scholarship selection, counseling, comparing classes, and in relation to requests for deferment, a section is devoted to reporting the results from research studies. The six appendixes contain useful statistical and research information.

Gray, Duncan, and Davis (33) studied the validity of the *Iowa Legal Aptitude Test* as a predictor of first-year law grades. The obtained validity coefficients were significant but low. Martin (59) attempted to predict graduation from a law school and performance on state bar examinations from scores on a battery of entrance tests. The graduates were superior to the nongraduates on the entrance tests. Some parts of the *Iowa Legal Aptitude Test* contributed significantly to prediction.

Capps and DeCosta (11) sought to determine the extent to which *Graduate Record Examination* scores, *National Teacher Examinations* scores, and undergraduate grade-point averages were related to graduate-school success for students who were primarily teachers and teacher candidates. Multiple correlations of .57 to .59 were obtained by using various combinations of the predictor variables.

Das (16) presented a review of the literature on the selection of medical students. He concluded that so-called medical or professional aptitude tests may sometimes prove useful for predicting medical-school achievement but only to a limited extent. Stalnaker (78) presented mean scores on the *MCAT* for applicants accepted by medical schools and for those not accepted. Melton (60) studied 102 male premedical freshmen at the University of Minnesota. At the end of the freshman year the variables which discriminated between students admitted to medical school and other students were high-school rank, *ACE Psychological Examination,* and first-year honor-point ratio.

Hill (44) reported correlations of pharmacy grades with the *ACE Psychological Examination,* the *Ohio State Psychological Examination,* the *Purdue Mathematical Training Test,* and the *Iowa Chemistry Test.* A multiple correlation of .61 was obtained by using the first three tests; the inclusion of the chemistry test failed to add to this value.

Miscellaneous

In a review of the pertinent literature Patterson (70) pointed out that comparatively little has been done on the prediction of success in trade-school training although the problem is as important as the prediction of success in college work because of the number of people involved. The best predictors have been tests of verbal intelligence, mechanical information, and spatial ability. In another study Patterson (71) concluded that persistence in trade-school training could be predicted to a significant degree with the battery he tried out, but that much improvement was still needed. French (27) administered an extensive battery of aptitude and interest measures in two vocational and technical high schools. There were a number of tests with validity coefficients suitable for comparative prediction of success in different shop courses; the prediction of occupational criteria was less satisfactory.

Lee (56) analyzed tests of general intellectual ability and of fundamental processes in mathematics at five grade levels. She found three factors indicating "an organization of mental abilities corresponding to the hypothetical structure of mathematical thinking upon which the ability tests were based." Hills (45) obtained the validities of eight cognitive factors for grades in calculus, college mathematics, and ratings by instructors. The verbal score of the *Junior Scholastic Aptitude Test* was shown by Traxler (84) to have a moderate validity for predicting achievement in first-year French and Latin.

Rimland (73) reported on the development and validation of new forms of the *NROTC Contract Student Selection Test.* Although the new forms were more reliable and of more appropriate difficulty for college freshmen, they were no more valid for first-semester grades. Allison (1) studied the relationships between test scores and training-course grades for recruits from different backgrounds. The regression of school grades on predictor variables was sufficiently different for the two groups for him to recommend separate selection procedures for them.

Lauer (54) found group paper-and-pencil tests to be somewhat more valid than certain psychophysical tests for selecting Army driver personnel. Fleishman (22) developed and adapted some auditory tests for the selection of radiotelegraphers; the new tests were more highly related to a rate-of-learning code score than were the aptitude tests then in use. A factor analysis by Fleishman, Roberts, and Friedman (26) indicated that the code learning criterion had loadings on *Speed of Closure, Auditory Rhythm Perception,* and *Auditory Perceptural Speed* factors.

Ghiselli (31) made an extensive survey of the validity of tests for training criteria and occupational proficiency. He concluded that performances in training and on the job involve very different patterns of abilities, and that training criteria are more predictable than job performance. Rusmore and Toorenaar (74) used cost-accounting procedures to demonstrate the considerable savings that could be realized from the selection of applicants for telephone operator training by means of a battery of three valid tests. Cantoni (10) found that grade-point average, *Kuhlmann-Anderson Intelligence Test* scores, and scores on the *Bell Adjustment Inventory* had moderate relationships to later occupational status for a group of male students.

As Thorndike (81) pointed out in the previous review of this topic, the "Validity Information Exchange" section of *Personnel Psychology* is a good source for validity data, especially for the *USES General Apti-*

tude Battery and other occupational tests. A validity report section for educational and psychological tests now appears in *Educational and Psychological Measurement.*

Bibliography

1. ALLISON, ROGER B., JR. "Differential Performance of Fleet and Recruit Personnel in Torpedoman's Mates School." *Journal of Applied Psychology* 39: 393-96; December 1955.
2. ANDERSON, PAULINE K. "The Use of the General Aptitude Test Battery in the Employment Service." *Proceedings of the 1955 Invitational Conference on Testing Problems.* Princeton, N. J.: Educational Testing Service, 1956. p. 16-21.
3. BENNETT, GEORGE K. *The D.A.T.—A Seven Year Follow-Up.* Test Service Bulletin, No. 49. New York: Psychological Corporation, 1955. 8 p.
4. BENNETT, GEORGE K.; SEASHORE, HAROLD G.; and WESMAN, ALEXANDER G. "The Differential Aptitude Tests: An Overview." *Personnel and Guidance Journal* 35: 81-91; October 1956.
5. BERGER, RAYMOND M.; GUILFORD, JOY P.; and CHRISTENSEN, PAUL R. *A Factor-Analytic Study of Planning Abilities.* Psychological Monographs, No. 435. Washington, D. C.: American Psychological Association, 1957. 31 p.
6. BLADE, MARY F., and WATSON, WALTER S. *Increase in Spatial Visualization Test Scores During Engineering Study.* Psychological Monographs, No. 397. Washington, D. C.: American Psychological Association, 1955. 13 p.
7. BOND, GUY L., and CLYMER, THEODORE W. "Interrelationship of the SRA Primary Mental Abilities, Other Mental Characteristics, and Reading Ability." *Journal of Educational Research* 49: 131-36; October 1955.
8. BOYCE, JAMES E. *Comparison of Methods of Combining Scores To Predict Academic Success in a Co-operative Engineering Program.* Doctor's thesis. Lafayette, Ind.: Purdue University, 1955. 76 p. Abstract: *Dissertation Abstracts* 15: 2286; No. 11, 1955.
9. BRAYFIELD, ARTHUR H., and MARSH, MARY M. "Aptitudes, Interests and Personality Characteristics of Farmers." *Journal of Applied Psychology* 41: 98-103; April 1957.
10. CANTONI, LOUIS J. "High School Tests and Measurements as Predictors of Occupational Status." *Journal of Applied Psychology* 39: 253-55; August 1955.
11. CAPPS, MARIAN P., and DECOSTA, FRANK A. "Contributions of the Graduate Record Examinations and the National Teacher Examinations to the Prediction of Graduate School Success." *Journal of Educational Research* 50: 383-89; January 1957.
12. CRAWFORD, JOHN E., and CRAWFORD, DOROTHEA M. *Crawford Small Parts Dexterity Test.* New York: Psychological Corporation, 1956.
13. CROWDER, NORMAN A. "The Holzinger-Crowder Uni-Factor Tests." *Personnel and Guidance Journal* 35: 281-87; January 1957.
14. CURETON, EDWARD E. "Service Tests of Multiple Aptitudes." *Proceedings of the 1955 Invitational Conference on Testing Problems.* Princeton, N. J.: Educational Testing Service, 1956. p. 22-39.
15. CURETON, EDWARD E., and OTHERS. *The Multi-Aptitude Test.* New York: Psychological Corporation, 1955.
16. DAS, R. C. "The Selection of Medical Students." *Occupational Psychology* 30: 27-42; January 1956.
17. DRAKE, RALEIGH M. *Drake Musical Aptitude Tests.* Chicago: Science Research Associates, 1954.
18. DVORAK, BEATRICE J. "The General Aptitude Test Battery." *Personnel and Guidance Journal* 35: 145-52; November 1956.
19. EDUCATIONAL TESTING SERVICE. *Annual Report to the Board of Trustees, 1954-1955.* Princeton, N. J.: the Service, 1956. 140 p.
20. FLANAGAN, JOHN C. "The Flanagan Aptitude Classification Tests." *Personnel and Guidance Journal* 35: 495-504; April 1957.
21. FLEISHMAN, EDWIN A. "A Comparative Study of Aptitude Patterns in Unskilled and Skilled Psychomotor Performances." *Journal of Applied Psychology* 41: 263-72; August 1957.

22. FLEISHMAN, EDWIN A. "Predicting Code Proficiency of Radiotelegraphers by Means of Aural Tests." *Journal of Applied Psychology* 39: 150-55; June 1955.
23. FLEISHMAN, EDWIN A. *Predicting Success in Certain Aircraft Maintenance Specialties by Means of Manipulative Tests.* U. S. Air Force Personnel and Training Research Center, Research Report 55-23. Lackland Air Force Base, Texas: Personnel and Training Research Center, September 1955. 30 p.
24. FLEISHMAN, EDWIN A. "Psychomotor Selection Tests: Research and Application in the United States Air Force." *Personnel Psychology* 9: 449-67; Winter 1956.
25. FLEISHMAN, EDWIN A., and HEMPEL, WALTER E., JR. "Factorial Analysis of Complex Psychomotor Performance and Related Skills." *Journal of Applied Psychology* 40: 96-104; April 1956.
26. FLEISHMAN, EDWIN A.; ROBERTS, MILLARD M.; and FRIEDMAN, MORTON P. "A Factor Analysis of Aptitude and Proficiency Measures in Radiotelegraphy." *Journal of Applied Psychology* 42: 129-35; April 1958.
27. FRENCH, JOHN W. *Educational and Occupational Validation of a High School Comparative Prediction Battery (Pilot Study).* Research Bulletin 56-1. Princeton, N. J.: Educational Testing Service, February 1956. 45 p.
28. FRENCH, JOHN W. "The Factorial Invariance of Pure-Factor Tests." *Journal of Educational Psychology* 48: 93-109; February 1957.
29. FRENCH, JOHN W. "The Logic of and Assumptions Underlying Differential Testing." *Proceedings of the 1955 Invitational Conference on Testing Problems.* Princeton, N. J.: Educational Testing Service, 1956. p. 40-48.
30. GAIER, EUGENE L. "Technique of Problem Solving as a Predictor of Achievement in a Mechanics Course." *Journal of Applied Psychology* 39: 416-18; December 1955.
31. GHISELLI, EDWIN E. "The Measurement of Occupational Aptitude." *University of California Publications in Psychology* 8: 101-216; December 1955.
32. GORDON, MARY A. "Patterns of Mechanical Background and Aptitude." *Educational and Psychological Measurement* 17: 408-15; Autumn 1957.
33. GRAY, CARLINGFORD; DUNCAN, KASPAR T.; and DAVIS, JUNIUS A. "A Validation Study of the Iowa Legal Aptitude Test." *Educational and Psychological Measurement* 15: 499-501; Winter 1955.
34. GUILFORD, JOY P. "Les Dimensions de l'Intellect." *L'Analyse Factorielle et ses Applications.* (Edited by H. Laugier.) Paris: Centre National de la Recherche Scientifique, 1955. p. 55-77.
35. GUILFORD, JOY P. "The Guilford-Zimmerman Aptitude Survey." *Personnel and Guidance Journal* 35: 219-24; December 1956.
36. GUILFORD, JOY P. "New Frontiers of Testing in the Discovery and Development of Human Talent." *Seventh Annual Western Regional Conference on Testing Problems.* Los Angeles: Educational Testing Service, 1958. p. 20-32.
37. GUILFORD, JOY P. *A Revised Structure of Intellect.* Reports from the Psychological Laboratory, No. 19. Los Angeles: University of Southern California, April 1957. 27 p.
38. GUILFORD, JOY P. "The Structure of Intellect." *Psychological Bulletin* 53: 267-93; July 1956.
39. GUILFORD, JOY P. "A System of the Psychomotor Abilities." *American Journal of Psychology* 71: 164-74; March 1958.
40. GUILFORD, JOY P., and LACEY, JOHN I., editors. *Printed Classification Tests.* AAF Aviation Psychology Research Program Reports, No. 5. Washington, D. C.: Superintendent of Documents, Government Printing Office, 1947. 919 p.
41. GUILFORD, JOY P., and ZIMMERMAN, WAYNE S. *The Guilford-Zimmerman Aptitude Survey with Manual of Instructions and Interpretations.* Second edition. Beverly Hills, Calif.: Sheridan Supply Co., 1956.
42. HALL, ROBERT C. "Occupational Group Contrasts in Terms of the Differential Aptitude Tests: An Application of Multiple Discriminant Analysis." *Educational and Psychological Measurement* 17: 556-67; Winter 1957.
43. HARRISON, ROSS; HUNT, WINSLOW; and JACKSON, THEODORE A. "Profile of the Mechanical Engineer: I. Ability." *Personnel Psychology* 8: 219-34; Summer 1955.
44. HILL, SUZANNE D. "The Relationship Between Grades and a Predictive Test Battery in the School of Pharmacy of the George Washington University." *Journal of Applied Psychology* 41: 61-62; February 1957.

45. HILLS, JOHN R. "Factor-Analyzed Abilities and Success in College Mathematics." *Educational and Psychological Measurement* 17: 615-22; Winter 1957.

46. HUGHES, JOHN L., and MCNAMARA, WALTER J. "Relationship of Short Employment Tests and General Clerical Tests." *Personnel Psychology* 8: 331-37; Autumn 1955.

47. ISAACSON, LEE E. "Predicting Success in the Work Experience Program." *Personnel and Guidance Journal* 33: 270-73; January 1955.

48. JOHNSON, A. PEMBERTON; OLSEN, MARJORIE A.; and WINTERBOTTOM, JOHN A. *The Law School Admission Test and Suggestions for Its Use: A Handbook for Law School Deans and Admissions Officers.* Princeton, N. J.: Educational Testing Service, 1955. 148 p.

49. JONES, MARGARET H., and CASE, HARRY W. "The Validation of a New Aptitude Examination for Engineering Students." *Educational and Psychological Measurement* 15: 502-508; Winter 1955.

50. KETTNER, NORMAN W.; GUILFORD, JOY P.; and CHRISTENSEN, PAUL R. "A Factor-Analytic Investigation of the Factor Called General Reasoning." *Educational and Psychological Measurement* 16: 438-53; Winter 1956.

51. KING, JOSEPH E., JR. "Factored Aptitude Series of Business and Industrial Tests." *Personnel and Guidance Journal* 35: 351-58; February 1957.

52. KIRKPATRICK, DONALD L. "The Minnesota Clerical Test." *Personnel Psychology* 10: 53-54; Spring 1957.

53. KIRKPATRICK, JAMES J. "Validation of a Test Battery for the Selection and Placement of Engineers." *Personnel Psychology* 9: 211-27; Summer 1956.

54. LAUER, ALVAH R. "Comparison of Group Paper-and-Pencil Tests with Certain Psychophysical Tests for Measuring Driving Aptitude of Army Personnel." *Journal of Applied Psychology* 39: 318-21; October 1955.

55. LAWSHE, CHARLES H., and STEINBERG, MARTIN D. "Studies in Synthetic Validity: I. An Exploratory Investigation of Clerical Jobs." *Personnel Psychology* 8: 291-301; Autumn 1955.

56. LEE, DORIS M. "A Study of Specific Ability and Attainment in Mathematics." *British Journal of Educational Psychology* 25: 178-89; November 1955.

57. LONGSTAFF, HOWARD P., and BELDO, LESLIE A. "Practice Effect on the Minnesota Clerical Test When Alternate Forms Are Used." *Journal of Applied Psychology* 42: 109-11; April 1958.

58. MCNAMARA, WALTER J., and HUGHES, JOHN L. "The Selection of Card Punch Operators." *Personnel Psychology* 8: 417-27; Winter 1955.

59. MARTIN, RICHARD R. *An Investigation of the Effectiveness of an Entrance Test Battery for Predicting Success in Law School.* Doctor's thesis. Philadelphia: Temple University, 1954. 207 p. Abstract: *Dissertation Abstracts* 16: 575-76; No. 3, 1956.

60. MELTON, RICHARD S. "Differentiation of Successful and Unsuccessful Premedical Students." *Journal of Applied Psychology* 39: 397-400; December 1955.

61. MENDICINO, LORENZO. "Mechanical Reasoning and Space Perception: Native Capacity or Experience." *Personnel and Guidance Journal* 36: 335-38; January 1958.

62. MICHAEL, WILLIAM B. "Differential Testing of High-Level Personnel." *Educational and Psychological Measurement* 17: 475-90; Winter 1957.

63. MICHAEL, WILLIAM B., and OTHERS. "The Description of Spatial Visualization Abilities." *Educational and Psychological Measurement* 17: 185-99; Summer 1957.

64. MITCHELL, BLYTHE C. "The Relation of High School Achievement to the Abilities Measured by the Holzinger-Crowder Uni-Factor Tests." *Educational and Psychological Measurement* 15: 487-90; Winter 1955.

65. MOLLENKOPF, WILLIAM G. "An Easier 'Male' Mechanical Test for Use with Women." *Journal of Applied Psychology* 41: 340-43; October 1957.

66. MORICI, ANTHONY R. "Relation Between the Scores on the A.I.A. Orientation Test with the A.I.A. Elementary, Advanced Accounting Tests and Accounting Grades." *Journal of Educational Research* 51: 549-52; March 1958.

67. MYERS, CHARLES T. *The Effects of Training in Mechanical Drawing on Spatial Relations Test Scores as Predictors of Engineering Drawing Grades.* Research Bulletin 58-4. Princeton, N. J.: Educational Testing Service, March 1958. 10 p.

68. NORTH, ROBERT D. "The Use of Multi-Factor Aptitude Tests in School Counseling." *Proceedings of the 1955 Invitational Conference on Testing Problems.* Princeton, N. J.: Educational Testing Service, 1956. p. 11-15.
69. OTTMAN, ROBERT W. *A Statistical Investigation of the Influence of Selected Factors on the Skill of Sight-Singing.* Doctor's thesis. Denton: North Texas State College, 1956. 286 p. Abstract: *Dissertation Abstracts* 16: 763; No. 4, 1956.
70. PATTERSON, CECIL H. "Predicting Success in Trade and Vocational School Courses: Review of the Literature." *Educational and Psychological Measurement* 16: 352-400; Autumn 1956.
71. PATTERSON, CECIL H. "The Prediction of Attrition in Trade School Courses." *Journal of Applied Psychology* 40: 154-58; June 1956.
72. PRESCOTT, GEORGE A. "Prediction of Achievement in Commercial Subjects." *Educational and Psychological Measurement* 15: 491-92; Winter 1955.
73. RIMLAND, BERNARD. *The Development and Validation of Forms 1 and 2 of the NROTC (Contract) Student Selection Test.* U. S. N. Bureau of Naval Personnel Technical Bulletin, No. 55-17. San Diego, Calif.: U. S. Naval Personnel Research Field Activity, August 1955. 41 p.
74. RUSMORE, JAY T., and TOORENAAR, GERARD J. "Reducing Training Costs by Employment Testing." *Personnel Psychology* 9: 39-44; Spring 1956.
75. SEASHORE, CARL E., and OTHERS. *Seashore Measures of Musical Talents.* New York: Psychological Corporation, 1956.
76. SEGEL, DAVID. "The Multiple Aptitude Tests." *Personnel and Guidance Journal* 35: 424-32; March 1957.
77. SORENSON, GARTH, and SENIOR, NOEL. "Changes in GATB Scores with College Training." *California Journal of Educational Research* 6: 170-73; September 1955.
78. STALNAKER, JOHN M. "The Study of Applicants, 1954-1955." *Journal of Medical Education* 30: 625-36; November 1955.
79. SUPER, DONALD E. "The Multifactor Tests: Summing Up." *Personnel and Guidance Journal* 36: 17-20; September 1957.
80. SUPER, DONALD E. "The Use of Multifactor Test Batteries in Guidance." *Personnel and Guidance Journal* 35: 9-15; September 1956.
81. THORNDIKE, ROBERT L. "Development and Applications of Tests of Special Aptitudes." *Review of Educational Research* 26: 14-25; February 1956.
82. THURSTONE, LOUIS L. *Primary Mental Abilities.* Psychometric Monographs, No. 1. Chicago: University of Chicago Press, 1938. 121 p.
83. THURSTONE, THELMA G. "The Tests of Primary Mental Abilities." *Personnel and Guidance Journal* 35: 569-77; May 1957.
84. TRAXLER, ARTHUR E. "Relationship of Certain Predictive Measures to Achievement in First-Year French and Latin." *Educational Records Bulletin* 66: 73-77; July 1955.
85. VINEYARD, EDWIN E. "A Longitudinal Study of the Relationship of Differential Aptitude Test Scores with College Success." *Personnel and Guidance Journal* 36: 413-16; February 1958.
86. WEBB, SAM C. "The Prediction of Achievement for First Year Dental Students." *Educational and Psychological Measurement* 16: 543-48; Winter 1956.
87. WHITTINGTON, R. W. T. "The Assessment of Potential Musical Ability in Secondary School Children." *Journal of Educational Psychology* 48: 1-10; January 1957.
88. WING, HERBERT D. "The Measurement of Musical Aptitude." *Occupational Psychology* 31: 33-37; January 1957.
89. WORSENCROFT, ROBERT R. "The Effect of Training on the Spatial Visualizing Ability of Engineering Students." *Journal of Engineering Drawing* 19: 7-12; February 1955.